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Editorial

Cutting and Packing

The area of "Cutting and Packing" (C&P) is still fascinating a large group of researchers and practitioners worldwide. This feature issue documents some of the recent developments in the area. After the ones edited by Dyckhoff and Wäscher (1990), Bischoff and Wäscher (1995), and Wang and Wäscher (2002) it is the fourth in a line of such issues which have been published over the years.

The first section of this issue contains two papers which – in the first place – are meant to provide "technical" support for interested individuals in the field. *Wäscher*, *Haussner*, *and Schumann* introduce an improved typology of C&P problems which allows for a more consistent, unified system of definitions and notations. Based on this typology, ESICUP – The EURO Special Interest Group on Cutting and Packing maintains a database of C&P publications, giving researchers and practitioners faster access to the relevant literature. This database is available at ESICUP webpage (http://www.apdio.pt/esicup/). In order to keep it up-to-date, authors are requested to categorize their papers in accordance with the suggested typology and report their publications to ESICUP. This has already been done with respect to the papers included here, and, in fact, also the structure of this issue is based on the proposed system. Similarly, the paper by *Fekete and van der Veen* is devoted to allow for an easier access to relevant (multi-dimensional) test problem instances, which can be used for fairer, more thorough comparisons of existing and newly developed algorithms. The authors introduce PackLib[2], an integrated library of benchmark problems. The XML data format supports linking the basic benchmark data with additional properties such as best known objective function values, run-times, but also bibliographic information, origin, etc.

The papers of the second section address problems of the placement type, in which a weakly heterogeneous assortment of small items has to be assigned to a set of large objects. The large objects are not sufficiently available to accommodate all small items, thus the value of the assigned small items has to be maximized. (For a more detailed definition of this and the subsequently mentioned problem types see Wäscher et al., 2006.) All papers deal with a particular specification of this problem type, namely the two-dimensional Single Large Object Placement Problem (2D SLOPP), in which the small items have to be placed (orthogonally) on a single large object. *Baldacci and Boschetti* introduce improved reduction procedures and a cutting plane approach for the computation of upper bounds. They further describe an enumeration scheme for the determination of an optimal solution. *Hadjiconstantinou and Iori* describe a hybrid genetic algorithm with elitist theory, immigration rate, heuristic on-line and tailored crossover operators. *Alvarez-Valdes*, *Parreno*, *and Tamarit* propose a tabu search algorithm, which comprises intensification and diversification procedures based on long-term memory. Numerical experiments demonstrate that the heuristics provide good results over a wide range of problem instances.

Papers of the third section are related to problems of the Knapsack type. Again, the large objects are not sufficiently available to accommodate all small items, and the value of the assigned small items has to be maximized. However, the assortment of small items is strongly heterogeneous now, i.e. there are no or only very few duplications,

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which makes it necessary to consider each small item individually. The Classic Knapsack Problem is obviously a member of this problem category, namely a One-Dimensional Single Knapsack Problem (1D SKP). In their paper, *Hoto*, *Arenales*, *and Maculan* consider an additional property, namely that the items which are to be packed belong to different classes. Items have to be assigned to compartments, each of which containing only items of a single class. They call this problem the Compartmentalised Knapsack Problem, which arises in real-world cutting problems in the steel and the paper industries. For a two-dimensional extension of the Classic Knapsack Problem, the Two-Dimensional Single Knapsack Problem (2D SKP), *Clautiaux*, *Carlier*, *and Moukrim* present two exact approaches, an improved Branch-and-Bound Method and a enumeration method. *Goncalves* introduces a new genetic algorithm for this problem. Finally, *Binkley and Hagiwara* propose a new heuristic (they call "four corners" heuristic) which is meant to be embedded in evolutionary algorithms in order to improve their search efficiency.

Problems of the Open Dimension type (ODP) form the fourth cluster of this feature issue. They are different to the problems dealt with in the preceding sections with respect to the property that all the small items can now be accommodated by the large object(s). More precisely, the extension of the large object(s) in at least one dimension can be considered as a variable. The part(s), or the value of the part(s) of the large object(s) necessary to accommodate all small items has to be minimised. The Strip-Packing Problem considered by *Egeblad*, *Nielsen*, *and Odgaard* is a typical two-dimensional representative of this problem type, in which the length of a single, rectangular large object is variable which has to minimized. In their paper, the small items have irregular shapes. The authors propose a guided local search method in which the neighbourhood is defined by any horizontal or vertical translation of a given polygon from its current position. They also present a modification of their method for a three-dimensional problem. A three-dimensional version of the ODP is also considered by *Bortfeldt and Mack*, namely the loading of a longitudinal container with a given set of (rectangular) boxes such that the required length of the container is minimized. They present a heuristic solution approach which is derived from a Branch-and-Bound method recently introduced into the literature. For the definition of problem types, Wäscher et al. (2006) refer to certain standard assumptions about characteristics of C&P problems. Replacing these standard assumptions by different ones gives rise to problem variants. One of the standard assumptions is that the large objects are rectangles. In the paper by *Hifi and M'Hallah*, the large object is a circle, which size (radius) – in the sense of the ODP – has to be minimized. Also, all the small items are circles.

The fifth section comprises papers which are dealing with problems of the Bin-Packing type. In these problems, a list of individual small items is given which have to be allocated to a set of large objects. All small items have to be assigned, and the large objects are in sufficient supply. Consequently, the value of the large objects, which have to be used in order to accommodate all small items, must be minimized. *Crainic*, *Perboli*, *Pezzuto*, *and Tadei* look at a one-dimensional specification of this problem type, in which all large objects are of the same size. This specification in fact leads to the Classic (one-dimensional) Bin Packing Problem, which – according to the newly introduced typology – is a Single Bin-Size Bin Packing Problem (1D SBSBPP). The authors address the issue of computing the asymptotic worst-case lower bound for this problem. *Puchinger and Raidl* deal with an extension of this problem into two dimensions (i.e. the 2D SBSBPP), but only admit guillotine cuts which can be obtain in at most three stages. They present new integer linear programming formulations for this problem, which involve polynomial numbers of variables and constraints and avoid symmetries. They also introduce a Branch-and-Price algorithm. *Cintra*, *Miyazawa*, *Wakabayashi*, *and Xavier* also deal with the SBSBPP, and they show that "well-behaved" approximation algorithms for one, two, and higher dimensional SBSBPP can be transformed into approximation algorithms for Single Stock-Size Cutting Stock Problems (SSSCSP), in which the small items have a given multiplicity. *Alves and de Carvalho* study different strategies for the stabilization and acceleration of column generation for what they call the (one-dimensional) Variable Sized Bin Packing Problem, which – according to the notation used here – is a Multiple Bin-Size Bin Packing Problem, i.e. a Bin Packing Problem with multiple bin sizes, each of which is available in a sufficiently large number.

The following two papers are not only dealing with the determination of layouts according to which the small items should be cut from/packed into the large objects, but also consider additional aspects of cutting/packing processes. Apart from set-up processes, in particular questions of order and pattern sequencing have attracted significant interest from researchers in the past. Extended problems of this kind are treated in the papers by *Yanasse and Lamosa* and by *Rinaldi and Franz*. The first paper is related to the Classic (one-dimensional) Multiple Stock-Size Cutting Stock Problem (1D MSSCSP), and the authors give an integrated formulation which aims at finding an optimal solution to this problem under particular pattern sequencing constraints. The proposed solution method uses a Langrangian approach, in which the dual problem is solved by means of a modified subgradient method. In the second paper, the "core" C&P problem is of the 2D ODP (more precisely: rectangular strip-packing) type. The authors present two heuristics which are based on a graph characterisation of the feasible solutions.

The final section of this feature issue is devoted to applications in industry. *Hajizadeh and Lee* look at a (one-dimensional) cutting problem in a steel tube mill, in which the major goal is to minimize the time necessary for cutting and sequencing the patterns. In terms of the typology of Wäscher et al. (2006), the problem considered in this paper contains elements of both an extended problem and a problem variant. They propose a new configuration of the cutting machines to achieve higher production efficiency. Another one-dimensional problem from the curtain industry is considered by *Alfieri*, *van de Velde and Woeginger*. In that problem, rolls of different lengths have to be cut down into smaller pieces of identical length. Problems of this kind are called Identical Item Packing Problems (IIPP) in the new typology (cf. Wäscher et al., 2006). What makes them special here are additional constraints which demand that the remaining parts of the rolls must either be sufficiently short (so that it represents trim loss) or sufficiently long (so that it can be stored and used in future for new orders). *Morabito and Belluzo* consider a two-dimensional problem in the hardboard industry, which can be characterized as one of the Multiple Stock-Size Cutting Stock type (2D MSSCSP). Additional constraints associated with longitudinal and transversal saws, head cuts, book rotation and others lead to a specific (special) problem. *Arbib and Marinelli* discuss a production problem from the glass industry in which glass parts are to be produced from flat glass. Ribbons have to be cut into sheets from which smaller, rectangular parts have to be produced. This leads to a combined two-dimensional assortment and trim-loss minimization problem (extended problem). Finally, *Sciomachen and Tanfani* look at an application from logistics, the problem of determining stowage plans for container ships. This (three-dimensional) problem consists of where to stow a set of containers of different types subject to structural and operational constraints imposed by both the containers and the ship.

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